FOREST CATERPILLARS

A COMPLEX NICHE IN THE ECOSYSTEM

MILLIONS OF CATERPILLARS

Caterpillars are surprisingly voracious eaters. In many forests, they devour more leaves than all other herbivores combined. Caterpillars are both diner and dinner, offering a tasty entrée to the birds, ants, and other predators who gobble them up. Certain flies, wasps, and nematode worms also depend on them for hatcheries. These **parasitoids** lay eggs on, or in, live caterpillars. When the eggs hatch, the tiny larvae that emerge feast on caterpillar flesh, and eventually kill their hosts. Caterpillars occupy a complex niche in forest ecosystems, influencing plants, predators, and parasitoids.

Despite their apparent importance, scientists know relatively little about caterpillars. Researchers have described about 15,000 species, but since 3.5 million are thought to exist, that's just a drop in a very large bucket. Scientists are more familiar with butterflies and moths, the adult forms of caterpillars. Even so, only 160,000 species of these have been catalogued. This has serious implications for caterpillar conservation, because protecting the earth's biological diversity requires knowledge.

Dr. Lee Dyer, an ecologist at Tulane University in New Orleans, is getting better acquainted with caterpillars in the rainforests of Costa Rica and Ecuador, and in the drier forests of Arizona. He studies their interactions with parasitoids to learn how each group helps maintain biodiversity. In the process, he has discovered many new species and established links between species of moths and butterflies and their previously unknown larvae.

COLLECTING CATERPILLARS

"Much of the collecting required the volunteer to gaze upwards, often into the sunlight, looking on the underside of the large banana leaves. A caterpillar on the leaf was perfectly colored to match its host. The greenish-yellow caterpillars tended to group near the main leaf vein. Another caterpillar species resembled the banana tree trunk. Volunteers had to get over personal fear of picking up these huge, furry caterpillars and also had to exert some force to pull them away from the tree."

— Sarah Craig,
Earthwatch Volunteer

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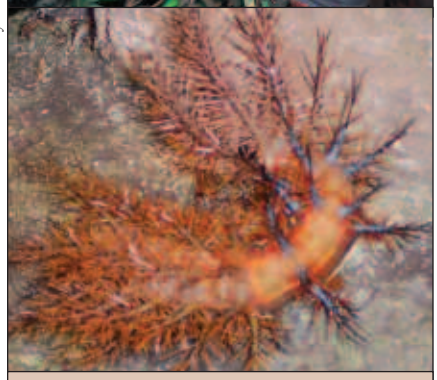

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Caring for caterpillars in Dyer's lab is no small endeavor. Often as many as 75 or 100 larvae are being kept at a time. During one research season, 1,170 caterpillars were reared at the La Selva site alone.

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FINDING AND REARING CATERPILLARS

The methods Dyer uses are not technically demanding, but they are very time-consuming. Volunteer assistants make the work possible. Each day, the team ventures out in search of moth and butterfly larvae. Roughly 5,000 species inhabit the area surrounding the La Selva Biological Station in Costa Rica, and the Yanayacu site in Ecuador is even more diverse. Nonetheless, finding caterpillars can be a challenge. Some blend in beautifully with green leaves or grayish-brown tree bark, while others are so tiny they are easily overlooked. Still others are perfect mimics, at first glance seeming to be twigs, bird droppings, or poisonous snakes. Volunteers keep a sharp lookout for clues that might lead to caterpillars. Chewed leaves and **frass**, or caterpillar droppings, are the most common.

When a team member finds a caterpillar, he or she collects it, along with a few leaves from the plant it was eating. Back in the lab, it is photographed, described in writing, and housed in a glass jar or clear plastic bag. Leaves are added for food. Twice a day, volunteers look in on each specimen. If parasitoids have emerged from its body, their presence is noted and they, too, are reared.

Caterpillars are kept until they die or **pupate**. They must be carefully tended, so each day fresh leaves are added and holding areas are cleaned. This is scientifically important as well as humane, because Dyer wants to determine the rate of parasitism for caterpillars at each research site. If unhealthy laboratory conditions cause larvae to die from various causes, accurate assessment is impossible. Caring for caterpillars in Dyer's lab is no small endeavor. Often as many as 75 or 100 larvae are being kept at a time. During one research season, 1,170 caterpillars were reared at the La Selva site alone.

Any unfamiliar caterpillars or parasitoids that have been reared in the lab are sent to scientists who specialize in insect identification. Sometimes, these creatures turn out to be new species that researchers haven't yet recognized or named. Then, a lengthy process of scientific description begins - one that can last as long as five years. The photographs, written descriptions, and observations made by Dyer and his team, as well as the insects themselves, contribute important data.

WILD DEFENSES

Documenting the diversity of caterpillars and their parasites is just one of Dyer's research goals. He is also investigating caterpillar defense mechanisms. Small size, mimicry, and cryptic coloration can make larvae hard for predators and parasitoids to find. Certain behaviors are protective too. **Gregarious** caterpillars stick together, feeding in groups. Solitary species may hide, rolling themselves up in leaves or surrounding their bodies with silken webs. Some caterpillars thrash around, vomit, or drop to the ground when disturbed. A few large species actually attack and injure enemies.

In addition to behavioral defenses, many caterpillars have **morphological** characteristics that offer some protection. Bristles or spines may deter predators from biting and parasitoids from depositing eggs. Some caterpillars have fake limbs that detach when a predator grabs hold, facilitating a quick escape.

Caterpillars also have physiological defenses derived from the protective strategies of their food plants. These plants contain chemicals that are toxic to most animals, reducing herbivore damage. However, some caterpillars have evolved the ability to tolerate plant poisons and incorporate them into their own tissues, which renders them **unpalatable** to would-be predators. These toxins can discourage parasitoids, too, as their larvae consume caterpillar flesh.

How effective are specific caterpillar defenses against different types of parasitoids? Dyer and his team are trying to find out. Each time they encounter a caterpillar in the field, they note all physical and behavioral defenses. In the lab, chemical analyses of caterpillars and their food plants yields information about toxins. Feeding experiments can also indicate chemical defenses. Caterpillar tissue is offered to giant tropical ants, which are more apt to reject those tissues laced with plant poisons. Armed with this data, and with information about parasitism rates gleaned from rearing caterpillars, Dyer looks for correlation between caterpillar species, defense mechanisms, and levels of parasitism.

Dyer's research has already led to some important findings. Dyer has found that while caterpillar-parasitoid dynamics in La

Selva and Yanayacu are similar, the "actors" in each forest are different. The two sites have warm temperatures and high rainfall in common, but they have few caterpillars and parasitoids in common. To further compare, Dyer has started gathering data in the drier forests of Arizona.

Dyer has also established that the rates of parasitism at La Selva and Yanayacu are very high - about 30 percent. In the temperate and dry tropical forests he has studied, rates are much lower. It may be that parasitoids are less abundant in drier forests because the relatively harsh conditions there make it harder for them to survive. It may also be difficult for parasitoids to deal with the **oscillations** in herbivore numbers that occur in forests with distinct wet and dry seasons. Dyer is testing other hypotheses, such as the possibility that particular plant defenses affect caterpillars and make them more susceptible to attack by parasitoids. One experiment involves *Piper cenocladum*, a tropical forest plant. Chemicals in Piper leaves may make caterpillars less able to defend themselves from parasitoids by **encapsulating** their eggs. Encapsulation is an immune response in which caterpillars surround parasitic eggs or larvae with special blood cells that suffocate or poison them. Dyer and his team study this process by injecting caterpillars with fake parasitoid eggs. Later, they dissect the caterpillars to see whether or not encapsulation has occurred.

USING PARASITOIDS ON PESTS

Dyer's work has important implications for agriculture, as many kinds of caterpillars pose a serious threat to crops. The enormous caterpillars that dwell on banana trees are a case in point. These larvae reach lengths of 15-20 centimeters, and one can devour an entire banana leaf in a day. **Defoliated** trees cannot produce fruit, so the people who manage banana plantations often spray poisons to kill caterpillar pests. This practice has consequences for plantation workers, who have complained of serious health problems after exposure to pesticides. It also pollutes the environment. Furthermore, spraying pesticides has sometimes backfired, increasing caterpillar numbers. It turns out that some pesticides killed wasps that parasitize banana caterpillars. In the absence of these parasitoids, caterpillars thrived.

Dyer hopes that advancing knowledge of caterpillar-parasitoid interactions can lead to more biologically responsible pest control. Since many wasps and flies attack crop pests, they can potentially be used in place of poisons. This has already been tried in some instances, but outcomes have varied. Dyer and his team are increasing the odds of success by providing information about pest caterpillars and their natural enemies. In addition, Dyer is developing statistical models that predict situations in which parasitoids will be effective biocontrol agents.

RAINFOREST COMMUNITIES: FRAGILE OR STRONG?

Wet tropical rainforests are the most diverse and complex ecosytems on Earth. What is not yet clear is whether this makes them extremely fragile or inherently stable. The strong interdependence among rainforest species could mean that a change in one population affects many others, with potentially catastrophic results. Alternatively, the complex web of relationships could buffer each group from disturbances. Dyer and Dr. Deborah Letourneau, a colleague at the University of California in Santa Cruz, are trying to answer this question. They devised an experiment involving the complex food web found on the tropical shrub *Piper cenocladum*. First, they catalogued the


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many insects, mites, worms, and other invertebrates inhabiting each of 80 *Piper* shrubs. Then, they introduced a new predator, the clerid beetle, to half. Fifteen months later, volunteers helped them count and catalogue the more than 40,000 invertebrates then living on the shrubs.

Dyer and Letourneau found that the invertebrate communities on the two groups of shrubs were significantly different. Clerid beetles, where present, had preyed upon ants, which were then present in fewer numbers to attack caterpillars, leading to a host of other changes. Introducing a new predator had produced direct and indirect effects, suggesting that the complex relationships of rainforest communities are indeed quite vulnerable to disturbance.

CLIMATE CHANGE AND CATERPILLARS

Today's climate change models are predicting an increase in extreme weather events, such as droughts and hurricanes, due to global warming. Numerous studies have suggested that insect outbreaks will increase in frequency and intensity with the projected changes in global climate. To understand how climate change might affect insect populations, such as caterpillars, Dyer is comparing the caterpillar-parasite interactions along a **climatic gradient** in the Americas.

Results from 14 long-term databases (including data from Dyer's three study sites) show three relationships between climatic variability and parasitism of caterpillars. First, overall parasitism decreases as climatic variability increases. Second, changes in latitude and temperature do not seem to explain increases or decreases in parasitism. And third, climatic variability seems to mostly affect the ability of parasites to find their caterpillar hosts. Dyer predicts that increases in extreme weather events will decrease parasitism of caterpillars, and so the populations of caterpillars may explode at times. Sudden outbreaks of caterpillars can have devastating effects on banana plantations, for example, causing economic problems, as well as on forest ecosystems. Dyer is continuing to study the relationships among caterpillars, parasites, and environmental conditions to get a better understanding of these complex ecosystems.

GLOSSARY

climatic gradient – a gradual transition along climate conditions, such as cold and dry to damp and hot

defoliate – to deprive (a plant, tree, or forest) of leaves

encapsulate – to encase in a small container

frass – debris or excrement produced by insects

gregarious – tending to move in or form a group with others of the same kind

morphological – relating to or concerned with the form and structure of an organism or one of its parts

niche – the function or position of an organism or population within an ecological community

oscillation – the act of swinging back and forth with a steady, uninterrupted rhythm

parasitoid – an insect that completes its larval development within the body of another insect, that it eventually kills and that is free-living as an adult

pupate – to become an insect in the inactive stage of development (when it is not feeding) intermediate between larva and adult

unpalatable – not pleasing to the taste

FIND OUT MORE

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Web Sites

Dyer's Caterpillar Site
http://www.tulane.edu/~ldyer/lsacat/index.htm

A Teacher's Experience
http://teacher.scholastic.com/activities/explorer/ecosystems/mission_caterpillars.asp

Key Words

Caterpillars, rain forest, parasites, Costa Rice, Ecuador, Arizona

Volunteers have joined this project through Earthwatch Institute. Read more about this study and other scientific field research at **www.earthwatch.org**.

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